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Indian Standard

SPECIFICATION FOR DIRECTLY HEATED POSITIVE STEP-FUNCTION TEMPERATURE COEFFICIENT THERMISTORS

PART 1 GENERAL REQUIREMENTS AND METHODS OF TESTS

UDC 621·316·825 : 621·1

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MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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October 1986

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Indian Standard

SPECIFICATION FOR DIRECTLY HEATED POSITIVE STEP-FUNCTION TEMPERATURE COEFFICIENT THERMISTORS

PART 1 GENERAL REQUIREMENTS AND METHODS OF TESTS

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*For the meeting in which this standard was recommended for finalization.

Indian Standard

SPECIFICATION FOR DIRECTLY HEATED POSITIVE STEP-FUNCTION TEMPERATURE COEFFICIENT THERMISTORS

PART 1 GENERAL REQUIREMENTS AND METHODS OF TESTS

0. FOREWORD

0.1 This Indian Standard (Part 1) was adopted by the Indian Standards Institution on 18 November 1985, after the draft finalized by the Resistors Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

0.2 The object of this standard (Part 1) is to lay down general conditions and methods of tests for directly heated positive step-function temperature coefficient thermistors.

0.3 The thermistors covered by this standard are generally intended for applications where a considerable change of resistance is required as a function of temperature or of dissipated power such as:

a) temperature indication, control or alarm;

b) compensatory circuits;

c) time delay of relays;

d) circuit protection; and

e) indication, measurement or detection of fluid levels, flow, etc.

0.4 This standard is largely based on IEC Pub 738-1(1982) 'Directly heated positive step-function temperature coefficient thermistors: Part 1 Generic specification', issued by the International Electrotechnical Commission (IEC).

1. SCOPE

1.1 This standard (Part 1) is applicable to directly heated positive temperature coefficient thermistors, insulated or non-insulated, having a resistance temperature characteristic which approximates to a step-function. Typically they are made of ferro-electric semi-conductive materials.

2. TERMINOLOGY

2.0 For the purpose of this standard, following terms and definitions shall apply.

2.1 Directly Heated Positive Step-Function Temperature Coefficient Thermistor (PTC-S)—A thermally sensitive semi-conductor resistor, which shows a step-like increase in its resistance when the increasing temperature reaches a specific value.

The change in temperature is obtained either by the flow of current through the thermosensitive element, or by a change in the ambient temperature, or by a combination of both these means. APTC-S thermistor may slow secondary effects which have to be taken into account (*see* **2.19** and **2.20**).

2.2 Zero-Power Resistance (R_m)—The dc resistance value of a thermistor measured at a specified temperature with a power dissipation low enough that any further decrease in power will result only in negligible change in resistance. Zero-power resistance may also be measured using ac if required by the detail specification.

2.3 Temperature/Resistance Characteristic—The relation at a specified direct voltage between the zero-power resistance of a PTC-S thermistor and the temperature of the thermosensitive element.

It is represented by a curve drawn on a semi-logarithmic coordinate graph (T or θ) in linear abscissa and R in logarithmic ordinates.

2.4 Rated Zero-Power Resistance (R_n) — The zero-power resistance at 25°C (298·15 K), unless another temperature is prescribed in the detail specification.

2.5 Minimum Resistance (R_{min}) — The zero-power resistance of the thermistor at temperature T_{Rmin} (or θ_{Rmin}) which is the lower limit of the PTC-S part of the resistance/temperature characteristic (*see* Fig. 1).

2.6 Switching Temperature T_m (or θ_b) — The specified temperature at which the step-like increase of the resistance occurs (*see* **2.1**).

2.7 Switching Resistance (R_b) — The value of zero-power resistance corresponding to the switching temperature.

NOTE — The switching resistance is expressed with reference to the minimum resistance (R_{min}) by a specified multiplying factor. It may also be expressed as an absolute value of resistance and independent of R_{min}.

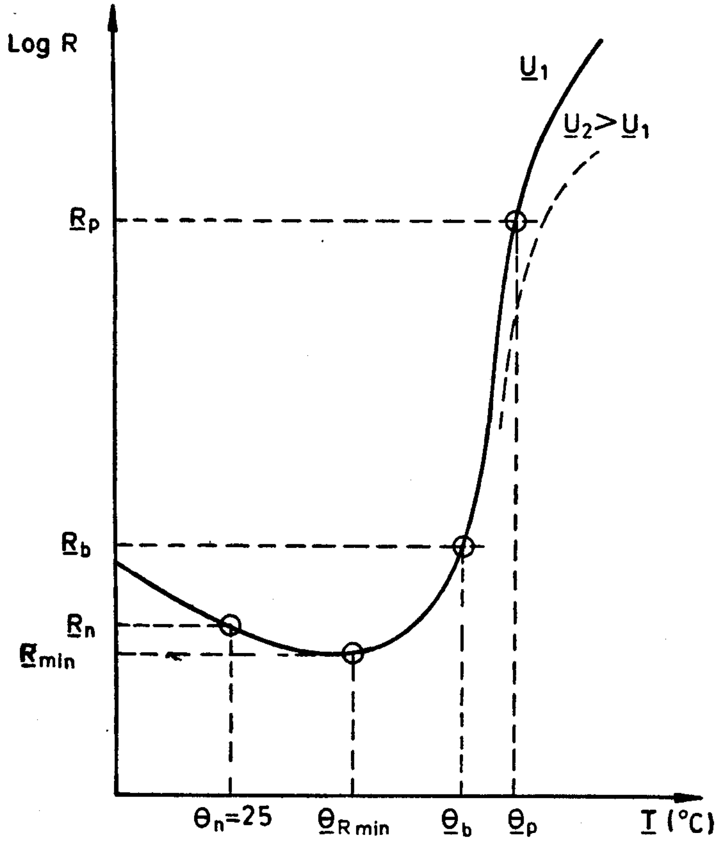

FIG. 1 TYPICAL RESISTANCE-TEMPERATURE CHARACTERISTIC AND DEFINITIONS FOR PTC-S THERMISTORS (AT ZERO-POWER)

2.8 Temperature T_P (or θ_p) — The chosen temperature in the PTC-S part of the resistance/temperature characteristic for which a minimum value R_P of the zero-power resistance is guaranteed.

2.9 Resistance R_P — The zero-power resistance at temperature T_p (or θ_p) measured at maximum voltage (*see* **2.13**) and given as a minimum value.

2.10 Temperature Coefficient at Zero-Power of the Resistance (α_T) — Temperature coefficient is defined at a temperature T by the relation:

$$\alpha_T = \frac{1}{R_T} \cdot \frac{dR}{d_T} T$$

The temperature coefficient of the positive coefficient part of the resistance/temperature characteristic (log R — lin T) of thermistors is defined as being the angular coefficient of the secant passing through points T_b and T_p of the characteristic.

For the secant, the logarithm of the resistance R is directly proportional to the temperature T.

$$\log R = A.T + B$$

$$\frac{dR}{dT} = \frac{AR}{\log e}$$

$$\alpha_T = \frac{A}{\log e}$$

$$\alpha_T = \frac{1}{\log e} \cdot \log \frac{R_p}{R_b} \cdot \frac{I}{T_p - T_b}$$

R_p and R_b must be measured at the same voltage, specified in the relevant detail specification.

NOTE — The detail specification may specify the measurement of the temperature coefficient of resistance in a narrow temperature range where its value is a maximum. The detail specification shall also then provide a method.

2.11 Maximum Ambient Temperature — The maximum ambient temperature at which the thermistor may be put into steady-state operation. At this temperature, the resistor should no longer dissipate power.

2.12 Maximum Voltage U_{Max} — The maximum direct voltage which may be continuously applied to the thermistor after switching at 25°C in still air (that is, to say for stable operation in the PTC-S range of the temperature resistance characteristic).

NOTE — Before switching, the current through the thermistor shall be limited, if necessary, by a series resistor R_s.

2.13 Dissipation Factor δ — The quotient of the change in power dissipation in a thermistor and the resultant temperature change of the element. This quotient is expressed in milliwatts per degree Celsius.

2.14 Thermal Time Constant γ — The time necessary for a thermistor to vary its temperature by 63·2 percent of the total difference between its initial temperature and its final temperature when it is subjected to a temperature step under zero-power conditions.

2.15 Calorific Capacity of a Thermistor C_{th} — The quantity of heat to be supplied to the thermistor to raise its temperature by 1°C. It is expressed in joules per degree Celsius.

2.16 Voltage/Current Characteristic — The relationship in still air at 25°C (unless otherwise stated) between the applied voltage (dc or ac) at the thermistor terminations and the current under steady-state conditions, thermal equilibrium having been reached (*see* Fig. 2).

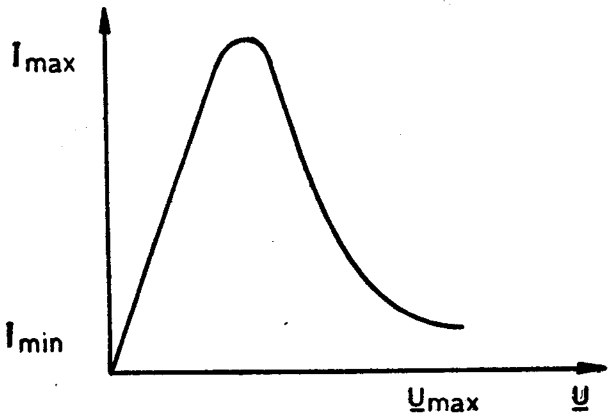

FIG. 2 VOLTAGE/CURRENT CHARACTERISTIC

NOTE — PTC-S thermistors may have more than one voltage/current characteristic (at different ambient temperatures).

2.17 Zero-Power Resistance Ratio — The zero-power resistance ratio characteristic identifies the ratio of the zero-power resistance of a thermistor measured at 25°C to that resistance measured at the temperature θ_p as specified in the detail specification.

2.18 Voltage Effect (VDR Effect) — At constant temperature and at zero-power, the resistance of a PTC-S thermistor depends on the voltage applied. This effect may be represented by means of the equivalent circuit given in Fig. 3 or by drawing the current/voltage characteristic at zero-power (pulse voltage).

The equivalent circuit of the thermistor has two parallel resistors, one R_2, having an ideal characteristic as a function of temperature, the other R_1 having an ideal characteristic as a function of voltage and complying with the law $U = CI^{B}$.

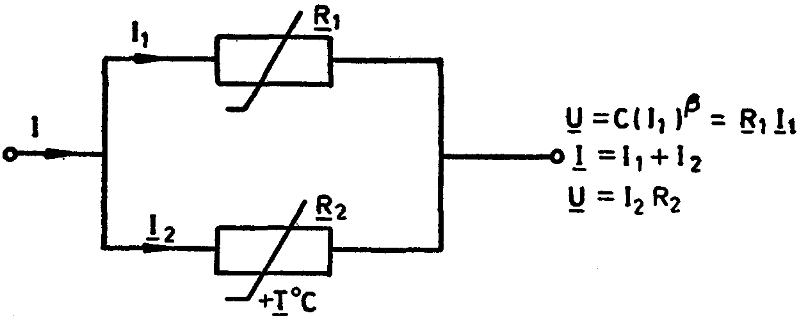

FIG. 3 EQUIVALENT CIRCUIT OF THE THERMISTORS FOR VOLTAGE EFFECT

The dependency between voltage and current is expressed by the value of β. It may be stated in the detail specification for a given temperature.

Equilibrium voltage (U_b) designates the voltage for which currents I_1 and I_2 are equal, when considering the equivalent circuit above.

2.19 Frequency Dependent Effect (for Information Only) — Reduction of the positive temperature coefficient of a PTC-S thermistor with the increase of the frequency of the applied voltage.

2.20 Insulated Thermistors (for Information Only) — Thermistors capable of meeting the requirements of the insulation resistance and voltage proof tests as specified in the test schedule.

2.21 Non-insulated Thermistors — Thermistors to which the isolation voltage and insulation resistance tests do not apply.

2.22 Rated Temperature Range — The ambient temperature range for which the thermistor has been designed for continuous operation; this range is limited on the one hand by the lower category temperature and on the other hand by the upper category temperature.

2.23 Temperature Range at Maximum Voltage — The ambient temperature range over which the maximum voltage may be applied to the thermistor in continuous operation.

3. TYPE DESIGNATION OF THERMISTORS

3.1 A thermistor complying with this standard is identified as follows:

a) By the type (*see* **3.2**);

b) By the rated zero-power resistance and its tolerance (*see* **3.3**);

c) By the classification (*see* **3.4**);

d) By the maximum voltage; and

e) By the zero-power resistance ratio (*see* **2.17**), if required by the detail specification.

3.2 Type

3.2.1 The type is characterized by:

a) design aspects (shape, coating, finish, outputs);

b) dimensions; and

c) climatic category.

Characteristics particular to one type are stated in the detail specification which will also contain the other characteristics necessary for identification purposes.

A type is designated by the group of letters PTC-S which represent all those thermistors covered by this standard, followed by a characteristic number, given in the detail specification.

3.2.2 *Associated Types* — These are types likely to be grouped together with a view to the same approval or same acceptance. These types shall have the same kind of terminations, the same form (insulated or not) and the same climatic category. Types which may be associated will be indicated in the detail specification.

3.3 Rated Zero-Power Resistance and Tolerance — The rated resistances and tolerances on these values are given in the detail specification.

3.4 Classification — PTC-S thermistors are classified according to the switching temperature.

The preferred classes are coded as shown below :

The switching temperatures and corresponding classification shall be given in the detail specification.

Class	θ_b (°C)
D	−80
E	− 60
F	−40
G	−20
H	0
J	+20
K	+40
L	+60
M	+80
N	+100
P	+120
R	+140
S	+160
T	+180
U	+200

4. MARKING

4.1 General

4.1.1 The information given in the marking shall be selected from the following list; the relative importance of each item is indicated by its position in the list:

a) Type designation,
b) Classification,
c) Rated zero-power resistance,
d) Tolerance,
e) Zero power resistance ratio (if required by the detail specification),
f) Manufacturer's name or trade-mark,
g) Maximum voltage,
h) Switching temperature, and
j) Year and month (or week) of manufacture.

4.1.2 The thermistor shall be clearly marked with **4.1.1**(a), (b) and (f) and with as many of the remaining items as is practicable. Any duplication of information in the marking on the thermistor should be avoided.

4.1.3 The package containing the thermistor(s) shall be clearly marked with all the information listed above.

4.1.4 Any additional marking shall be so applied that no confusion can arise.

4.2 Coding — When coding is used for resistance value, tolerance or date of manufacture, the method shall be selected from those given in IS : 8186-1976*.

4.3 The thermistors may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act and the Rules and Regulations made thereunder. The ISI Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard, under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions, under which a licence for the use of ISI Certification Mark may be granted to manufacturers or processors may be obtained from the Indian Standards Institution.

5. CLASSIFICATION OF TESTS

5.1 Type Tests

5.1.1 *Selection of Samples* — The sample shall be representative of the range of values for which approval is sought. This may or may not be the complete range covered by the detail specification.

The sample shall consist of specimens having:

a) the highest and the lowest resistance values for which approval is being sought, when there are several rated resistance values and only one switching temperature in the range being submitted;

b) the highest and the lowest switching temperature values for which approval is being sought, when there are several switching temperature values and only one rated resistance value in the range being submitted;

---

*Marking codes for values and tolerances of resistors and capacitors.

c) the highest resistance value together with the highest switching temperature value and the lowest resistance value together with the lowest switching temperature value for which approval is being sought, when there are several rated resistance values and several switching temperature values in the range being submitted; and

d) the resistance value and the switching temperature value, if approval is being sought for only one rated resistance value and only one switching temperature value.

Space specimens are permitted as follows:

a) One per resistance value and one per switching temperature value which may be used to replace the permitted defective in Group 'O'; and

b) One per resistance value and one per switching temperature value which may be used to replace specimens which are defective because of incidents not attributable to the manufacturer.

5.1.2 *Number of Samples* — The number of samples shall be 46.

NOTE — The thermistors subjected to type tests according to Table 1 shall not be used in equipment or returned to bulk supply.

5.1.3 *Schedule of Type Tests* — The thermistors shall be subjected to the tests as per Table 1 and in the order given. The whole sample, shall be subjected to the tests of Subgroup 'Oa' and then divided for the other groups. Specimens found defective during the tests of Group 'O' shall not be used for the other groups.

5.2 Routine Tests — The following shall constitute the routine tests:

a) Visual examination,

b) Dimensions,

c) Voltage proof (as a flash test), and

d) Zero-power resistance.

5.3 Acceptance Tests — For the purpose of acceptance of the lot, the thermistors shall be subjected to the tests specified in **5.2**. Following this, two groups of samples shall be selected and the thermistors in each group shall be subjected to the tests specified in relevant detail specification.

TABLE 1 SCHEDULE OF TYPE TESTS

(*Clauses* 5.1.2 *and* 5.1.3)

GROUP	NO. OF SPECIMENS	TEST	CLAUSE REF
(1)	(2)	(3)	(4)
GROUP O			
Subgroup Oa	46	Visual examination	7.2.1
		Dimensions	7.2.2
		Marking	
		Zero-power resistance	7.1.1
Subgroup Ob	26	Voltage proof (for insulated thermistors only)	7.1.6
		Insulation resistance (for insulated thermistors only)	7.1.7
Subgroup Oc	6	Dissipation factors	7.1.3
		Thermal time constant	7.1.4
GROUP 1			
Subgroup 1a	10*	Robustness of terminations	7.2.3
		Resistance to soldering heat	7.2.4.2
Subgroup 1b	6*	Solderability	7.2.4.1
		Vibration	7.2.6
		Bump	7.2.7
Subgroup 1c	6†	Rapid change of temperature	7.2.5
		Climatic sequence	7.2.8
GROUP 2	10*	Damp heat (steady state)	7·2.9
GROUP 3	10	Temperature coefficient at zero-power dissipation	7.1.2
		Endurance at maximum voltage	7.2.10.1
GROUP 4	10	Endurance at maximum ambient temperature at zero-power dissipation	7.2.10.2

*Specimens from subgroup Ob.

†These specimens are drawn from:

a) for one half, specimens that have passed the tests of subgroup 1a; and

b) for the other half, specimens that have passed the tests of subgroup 1b.

6. CENTRAL CONDITIONS FOR MEASUREMENTS

6.1 Unless specified otherwise, all the measurements shall be carried out under the following standard atmospheric conditions:

Temperature	15 to 35°C
Relative humidity	45 to 75 percent
Air pressure	860 to 1 060 mbar

6.2 Referee Conditions — The following referee conditions shall be maintained during the measurements where characteristics are sensitive to ambient conditions:

Temperature	25 ± 1°C
Relative humidity	65 ± 2 percent
Air pressure	860 to 1 060 mbar

6.3 Before the initial measurements of each group or subgroup, the specimens shall be stored under the standard conditions for testing for 24 h. Before the intermediate or final measurements the thermistors shall be placed in the recovery conditions for 4 ± 1 h.

7. TEST METHODS

7.1 Electrical Tests

7.1.1 *Zero-Power Resistance*

7.1.1.1 *Procedure* — The thermistors shall be fixed in corrosion resistant clamps by their usual means.

NOTE — A preferred means of mounting is given in Appendix A.

The thermistors are then immersed in an insulating medium not likely to cause deterioration, the temperature of which is maintained at the specified value.

The zero-power resistance is measured when it has stabilized.

The measuring method used shall be such that the total measuring error is less than 10 percent of the zero-power resistance tolerance, values otherwise stated in the detail specification.

The total measuring error is the sum of the errors due to:

a) temperature variation of the measuring medium,

b) temperature rise of the thermistor due to the measuring current (Joule effect), and

c) resistance measuring instrument.

7.1.1.2 *Requirement* — The zero-power resistance shall be within the specified tolerance.

7.1.2 *Temperature Coefficient at Zero-Power Dissipation* α_T

7.1.2.1 *Procedure* — The value R_p and R_b are measured at the same voltage specified in the relevant detail specification.

The temperature coefficient at zero-power α_T is calculated by means of the formula given in **2.10**.

7.1.2.2 *Requirement* — The temperature coefficient thus calculated shall be within the limits stated in the detail specification.

7.1.3 *Dissipation Factor* δ

7.1.3.1 *Procedure*

a) *Mounting* — The thermistors are held in accordance with one of the clamping methods shown in Appendix A, unless otherwise sepcified.

The distance (in millimetres) of the clamping point in relation to the body shall be stated in the detail specification. It is the highest value in the series 1-2.5-5 and decimal multiples compatible with the length of terminations.

When the terminations are insulated, measurements are carried out at their end-points, irrespective of their lengths.

b) *Initial measurement* — The zero-power resistance at 25°C shall be measured in accordance with **7.1.1**.

c) *Test* — The thermistors shall be introduced in still air at 25 ± 0·5°C in a test chamber, the voltage of which is at least 1 000 times that of the thermistors under test, in such a way that no thermistor is less than 75 mm from other thermistors or from the wall of the enclosure.

1) The voltage U_{max} is applied and the corresponding current I is measured. By calculation, the ratio $\frac{U_{max}}{I}$ and the corresponding power are deduced.

2) The resultant temperature increase is calculated:

$\Delta\theta = \frac{P}{\delta}$ (δ being the value stated in the datail specification).

3) Two measuring temperatures are calculated:

$$\theta_1 = 25 + \Delta\theta - 5$$
$$\theta_2 = 25 + \Delta\theta + 5$$

4) At temperatures θ_1 and θ_2, the values R_1 and R_2 of the zero-power resistance are measured for an applied voltage pulse having a peak value equal to U_{max}.

5) By interpolation, the temperature θ_3, at which the zero-power resistance is equal to $\frac{U_{max}}{I}$ is evaluated.

6) $\delta = \dfrac{P}{\theta_3 - 25}$

7.1.3.2 *Requirement* — The dissipation factor δ thus calculated shall correspond to the value stated in the detail specification, taking into account the tolerance.

7.1.4 *Thermal Time Constant* τ

7.1.4.1 *Procedure*

a) *Mounting* — The thermistors are held in position in accordance with one of the clamping methods shown in Appendix A, unless otherwise specified.

The distance (in millimetres) of the clamping point in relation to the body shall be stated in the detail specification. It is the highest value in the series 1-2.5-5 and decimal multiples compatible with the length of terminations.

When the terminations are insulated, measurements are carried out at their end-points, irrespective of their lengths.

b) *Test* — The thermistors shall be introduced in still air at temperature θ_0 ($\theta_0 = 25 \pm 0{\cdot}5°C$) in the test chamber described in 7.1.3.

Before introduction in the test chamber, the thermistors are inserted in the circuit shown in Fig. 4.

The high impedance voltmeter and the ammeter shall measure to an accuracy of 1 percent. The resistance measuring equipment shall measure to an accuracy of 0·1 percent or less.

Depending on the cases determined below, method A or B shall be used:

Method A

Applicable when : $\theta_3 - \theta_b > 63{\cdot}2$ percent $(\theta_3 - \theta_o)$

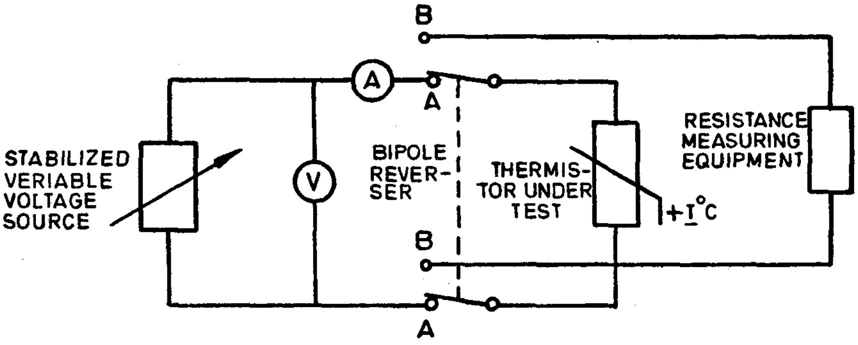
B
A
A
STABILIZED VERIABLE VOLTAGE SOURCE
V
BIPOLE REVER-SER
THERMIS-TOR UNDER TEST
RESISTANCE MEASURING EQUIPMENT
+1°C
B
A

FIG. 4 CIRCUIT DIAGRAM FOR MEASUREMENT OF THERMAL TIME CONSTANT

Initial measurements — R_{θ_3} and R_{θ_1} with $\theta_1 = \theta_3 - 0{\cdot}632\ (\theta_3 - \theta_0)$

With the contacts *AA* made, the voltage is so adjusted that the power dissipated in the thermistor raises its temperature to a value slightly above θ_3 (calculated as in **7.1.3**) and the indications of the instruments are stable.

The applied power may then, for example, be calculated as follows:

$$P = U.I = 1{\cdot}1\ (\theta_3 - \theta_0).\ \delta$$

where δ is the value calculated according to **7.1.3**.

Contacts *BB* are then made by means of the reverser and measurement of the time is started as soon as the resistance value has returned to $R\theta_3$ and the resistance measuring equipment is in balance.

Time measurement is stopped when the resistance measuring equipment indicates a value of $R\theta_1$.

The elapsed time *t* is noted. In this case, it represents the thermal time constant.

Method B

Applicable when : $\theta_3 - \theta_b \leqslant 63{\cdot}2$ percent $(\theta_3 - \theta_0)$

Initial measurements — R_{θ_3} and R_b

With the contacts *AA* made, the voltage is so adjusted that the power dissipated in the thermistor raises its temperature to a value slightly above θ_3 and the indications of the instruments are stable.

The applied power may then, for example, be calculated as follows:

$$P = U.I = 1{\cdot}1\,(\theta_3 - \theta_o).\,\delta$$

where δ is the value calculated according to **7.1.3**.

Contacts *BB* are then made by means of the reverser and measurement of the time is started as soon as the resistance value has returned to R_{θ_3} and the resistance measuring equipment is in balance.

Time measurement is stopped when the resistance measuring equipment indicates a value of R_b. The elapsed time t is noted, and the thermal time constant is then calculated as follows :

$$\tau = \frac{t}{\log_e \dfrac{\theta_3 - \theta_o}{\theta_b - \theta_o}}$$

NOTE 1 — For thermistors with low time constants, automatic switching should be provided between both resistance measurements, as well as for measuring the time interval between both equilibrium.

NOTE 2 — The power applied to the thermistor via the resistance measuring equipment shall be sufficiently low to cable the zero-power resistance of the thermistor to be measured.

7.1.4.2 *Requirement* — The thermal time constant shall correspond to the value given in the detail specification, taking into account the tolerance.

7.1.5 *Calorific Capacity*

NOTE — This does not describe a particular test, but enables information to be obtained which might be of interest to users.

7.1.5.1 *Calorific capacity* C_{th} *of a thermistor* — The calorific capacity C_{th} of a thermistor is deduced from the previous measurements by means of the formula:

$$C_{th} = \tau \times \delta$$

τ being the time constant

δ being the dissipation factor

7.1.5.2 *Calorific capacity of the ceramic alone (for information)* — The calorific capacitance of the ceramic alone is calculated in the same way.

The dissipation factor and thermal time constant are measured as previously, but the power shall be applied to the ceramic by means of connections of negligible thermal capacitance and high thermal resistance (for example platinum wires of 60 μm diameter).

7.1.6 *Voltage Proof (for Insulated Thermistors Only)* — According to the instructions given in the relevant detail specification, one of the following test methods is used.

7.1.6.1 *Method A* — The non-insulated parts of the thermistor shall be wrapped in insulating material of very high insulation value.

The whole is inserted into a box containing lead balls of 1·6 ± 0·2 mm diameter, in such a manner that only the connections of the thermistor emerge. An electrode is inserted into the lead balls.

7.1.6.2 *Method B* — A metal foil shall be wrapped closely around the body of the thermistor. For those types not having axial leads, a space of 1mm to 1·5 mm shall be left between the edge of the foil and each termination. For those types having axial leads, the foil shall be wrapped around the whole body of the thermistor protruding by at least 5 mm from each end, provided that the minimum space of 1 mm between the foil and each termination is maintained. The ends of the foil shall not be folded over the ends of the thermistor.

7.1.6.3 *Method C* — The thermistor shall be clamped in the trough of a 90° metallic V-block of such size that the thermistor body does not extend beyond the extremities of the block.

The clamping force shall be such as to maintain adequate contact between the thermistor and the block.

The terminations shall be so positioned that the distance between the terminations and any point of the V-block is not less than:

a) For cylindrical thermistors : the thermistor shall be positioned in the block so that the termination furthest from the axis of the thermistor is nearest to one of the faces of the block.

b) For rectangular thermistors : the thermistor shall be positioned in the block so that the termination nearest to the edge of the thermistor is nearest to one of the faces of the block.

For cylindrical and rectangular thermistors with axial leads, any out-of-centre positioning of the point of emergence of the terminations from the thermistor body shall be ignored.

Test

An alternating voltage of a frequency of 40 to 60 Hz, with a peak value of 700 V, unless otherwise stated in the detail specification, is applied for 1 min ± 5 s between the terminations of the thermistor connected to each other to form one pole, and, depending on the method of mounting used, with the electrode inserted in the lead balls, or the metal sheet, forming the other pole.

The voltage shall be applied progressively with a maximum step of 100 V per second.

7.1.6.4 *Requirement* — No puncture, flashover or discharge shall occur.

7.1.7 *Insulation Resistance Procedure (for Insulated Thermistors Only)*

As specified in the detail specification, one of the methods of mounting given in **7.1.6** shall be used.

The insulation resistance is measured under a dc voltage of 100±15 V, unless otherwise stated in the detail specification, between the terminations of the thermistors interconnected to form one pole, and, depending on the method of mounting used, the electrode inserted in the metal ball bearings or the metal sheet forming the other pole.

The voltage shall be applied for one minute, or for a shorter period but sufficient to obtain a stable reading. The insulation resistance is noted at the end of each period.

7.1.7.1 *Requirement* – Minimum insulation resistance. As specified in the detail specification.

7.2 Environmental Tests

7.2.1 *Visual Examination* — The thermistors shall be visually examined for the requirements of marking and finish.

7.2.2 *Dimensions* — The dimensions shall be checked for compliance with those specified the detail specification.

7.2.3 *Robustness of Terminations*

7.2.3.1 *Procedure* — The test shall be carried out in accordance with Sections 1, 3 and 4 of IS : 9000 (Part 19)-1978*, with the following particular requirements.

7.2.3.2 *Initial measurement* — The zero-power resistance at 25°C shall be measured in accordance with **7.1.1**.

7.2.3.3 *Tensile test* — The loading weight to be applied for 10 s shall be:

For all types of terminations, except wire terminations : 20 N.

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*Basic environmental testing procedures for electronic and electrical items : Part 19 Test for robustness of terminations and integral mounting devices,
Section 1 Tensile test;
Section 3 Bending test; and
Section 4 Torsion test.

For wire terminations, as given below:

Nominal Cross-Sectional Area mm²	*Corresponding Diameter for Circular-Section Wires* mm	*Force* N
$S \leqslant 0\cdot05$	$d \leqslant 0\cdot25$	1
$0\cdot05 < S \leqslant 0\cdot07$	$0\cdot25 < d \leqslant 0\cdot3$	2·5
$0\cdot07 < S \leqslant 0\cdot2$	$0\cdot3 < d \leqslant 0\cdot5$	5
$0\cdot2 < S \leqslant 0\cdot5$	$0\cdot5 < d \leqslant 0\cdot8$	10
$0\cdot5 < S \leqslant 1\cdot2$	$0\cdot8 < d \leqslant 1\cdot25$	20
$1\cdot2 < S$	$1\cdot25 < d$	40

7.2.3.4 *Bending test* — (half the number of terminations). Two consecutive bends shall be applied.

7.2.3.5 *Torsion test* — (other half of the terminations). Two rotations of 180°C shall be applied.

7.2.3.6 *Visual examination* — After each of these tests, the thermistors shall be visually examined. There shall be no visible damage.

7.2.3.7 *Final measurements and requirements* — After the test, the zero-power resistance shall be measured according to **7.1.1.** The change of resistance compared with the value measured in **7.2.1.2** shall not exceed the limit specified in the detail specification.

7.2.4 *Soldering*

7.2.4.1 *Solderability*

Procedure — The test shall be carried out in accordance with IS : 9000 (Part 18/Sec 1)-1981[*] with the following particular requirements:

Test

a) Bath method (unless otherwise stated in the detail specification), and

b) Procedure : the terminations shall be immersed in turn up to 6 mm from the body of the component.

NOTE — For thermistors intended to be used only on printed boards the test procedure shall be laid down in the detail specification.

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[*] Basic environmental testing procedures for electronic and electrical items: Part 18 Solderability test, Section 1 Solderability of wire and tag terminations.

Requirement

The terminations shall be examined for good tinning as evidenced by free flowing of the solder with wetting of the terminations.

7.2.4.2 *Resistance to soldering heat*

Procedure — The test shall be carried out in accordance with IS : 9000 (Part 18/Sec 2)-1981* with the following particular requirements:

a) *Initial measurement* — The zero-power resistance at 25°C shall be measured in accordance with **7.1.1.**

b) *Test* — Bath method 1A (unless otherwise stated in the detail specification).

Procedure — The terminations shall be immersed in turn up to 6 mm from the body of the thermistor.

Note — For thermistors intended to be used only on printed boards the test procedure shall be laid down in the detail specification.

c) *Final inspection and measurements*

   1) Visual examination, and

   2) The zero-power resistance at 25°C shall be measured in accordance with **7.1.1.**

d) *Requirements*

   1) There shall be no mechanical deterioration, and

   2) Maximum change of resistance — As specified in the detail specification.

7.2.5 *Rapid Change of Temperature*

Procedure — The test shall be carried out in accordance with IS : 9000 (Part 14/Sec 1)-1978* with the following particular requirements.

7.2.5.1 *Initial measurement* — The zero-power resistance at 25°C shall be measured in accordance with **7.1.1.**

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*Basic environmental testing procedures for electronic and electrical items :
Part 18 Solderability test, Section 2 Resistance of items to soldering heat.
Part 14 Change of temperature, Section 1 Solderability of wire and tag terminations.

Required temperatures — Minimum temperature of the climatic category limited to −55°C and the maximum temperature of the climatic category. The number of cycles and duration of exposure shall be prescribed in the relevant detail specification.

7.2.5.2 *Final inspection and measurements*

a) Visual examination,

b) Marking, and

c) Zero-power resistance at 25°C.

7.2.5.3 *Requirements*

a) There shall be no mechanical deterioration,

b) Marking shall remain legible, and

c) Maximum change of resistance — As specified in the detail specification.

7.2.6 *Vibration*

Procedure — The test shall be carried out in accordance with IS : 9000 (Part 8)-1981* with the following particular requirements.

7.2.6.1 *Initial measurement* — The zero-power resistance at 25°C shall be measured in accordance with **7.1.1**.

Mounting

For thermistors usually held by their connection wires:

a) Thermistors with axial terminations : the connection wires held in the position stated in the detail specification shall be fixed to a rigid support 6 ± 1 mm from the body of the thermistor;

b) Thermistors with radial terminations : at the clamping point given in the detail specification.

For other thermistors : Fixed in accordance with the usual method of attachment or, if this does not exist, in accordance with the requirements given in the detail specification on a rigid support integral with the vibration apparatus.

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*Basic environmental testing procedures for electronic and electrical items: Part 8 Vibration (sinusoidal) test.

7.2.6.2 *Test*

a) Frequency range — 10 to 55 Hz (unless otherwise prescribed in the detail specification);

b) Amplitude — 0·75 mm (or acceleration 100 m/s^2);

c) Duration — 6 h; and

d) Direction of vibration application — one direction parallel to the terminations, two directions perpendicular to the first, one of which is parallel to the likely place of the terminations.

7.2.6.3 *Final inspection and measurements*

a) Visual examination, and

b) The zero-power resistance at 25°C shall be measured in accordance with **7.1.1** before dismantling from the support where components have been soldered in order to undergo the tests.

7.2.6.4 *Requirements*

a) There shall be no mechanical deterioration, and

b) Maximum change of resistance : As specified in the detail specification.

7.2.7 *Bump* — Under consideration.

7.2.8 *Climatic Sequence*

Procedure — This test shall be carried out in accordance with IS : 9000 (Part 1)-1977* with the following particular requirements.

7.2.8.1 *Initial measurement* – The zero-power resistance at 25°C shall be measured in accordance with **7.1.1**.

7.2.8.2 *Dry heat test* — The thermistors shall be subjected to this test in accordance with IS : 9000 (Part 3/Sec 5)-1977* with the degree of severity appropriate the climatic category, for 16 h.

They shall then be placed under standard recovery conditions until the end of the 24 h period.

7.2.8.3 *Damp heat cyclic, first cycle* — The thermistors shall be subjected to the test specified in IS : 9000 (Part 5/Sec 1) - 1981*, severity of 55°C.

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*Basic environmental testing procedures for electronic and electrical items :
Part 1 General.
Part 3 Dry heat test, Section 5 Dry heat test for heat dissipating items with gradual change of temperature.
Part 5 Damp heat (cyclic) test, Section 1 6 + 8 h cycle.

7.2.8.4 *Cold* — The thermistors shall be subjected to this test in accordance with IS : 9000 (Part 2/Sec 4)-1977* with the degree of severity appropriate to the climatic category, for 16 h. They shall then be placed under standard recovery conditions until the end of the 24 h period.

7.2.8.5 *Low air pressure* (*optional*) — The test shall be carried out in accordance with IS : 9000 (Part 13)-1981* with the following particular requirements:

Initial measurements — No initial measurements shall be carried out.

Mounting — The method of mounting used (a or b) (*see* **7.1.6**) shall be stated in the detail specification.

a) Required pressure — 20 mbar;

b) Operation — application of the voltage proof test, in accordance with **7.1.6** at the voltage given in the detail specification; and

c) Duration of low pressure — the time needed to carry out the voltage proof test.

Requirement — No breakdown, flashover or discharge shall occur.

7.2.8.6 *Damp heat, cyclic, remaininig cycles* — The thermistors shall be subjected to this test in accordance with IS : 9000 (Part 5/Sec 1)-1981* for the following number of cycles:

For severity of 56 days — 5 cycles

For severity of 21 days — 1 cycle

Final inspection and measurements

a) Visual examination

b) Marking

c) Zero-power resistance (in accordance with **7.1.1**)

d) Voltage proof (in accordance with **7.1.6**) } For insulated thermistors only

e) Insulation resistance (in accordance with **7.1.7**) } For insulated thermistors only

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*Basic environmental testing procedures for electronic and electrical items :
Part 2 Cold test, Section 4 Cold test for heat dissipating items with gradual change of temperature.
Part 13 Low air pressure test.
Part 5 Damp heat (cyclic) test, Section 1 6 + 8 cyclic.

Requirements

a) There shall be no mechanical deterioration:

b) Marking shall remain legible;

c) Maximum change of resistance : in accordance with the limits stated in the detail specification;

d) No breakdown, flashover or discharge shall occur; and

e) Minimum insulation resistance : as specified in detail specification.

7.2.9 *Damp Heat, Steady State*

Procedure — The test is carried out in accordance with IS : 9000 (Part 4)-1979* with the following particular requirements:

Initial measurements — The zero-power resistance at 25°C shall be measured in accordance with **7.1.1**.

Test

a) Severity : dependent on the climatic category.

b) Operation (for insulated thermistors only) : A direct voltage shall be applied to the thermistors throughout the test. The voltage value is taken from the R 5 series range of values. It is limited to the value immediately less than 1/20th of the maximum voltage.

Final inspection and measurements

a) Visual examination,

b) Marking,

c) Zero-power resistance at 25°C (in accordance with **7.1.1**),

d) Voltage proof (in accordance with **7.1.6**), and
e) Insulation resistance (in accordance with **7.1.7**)
} For insulated thermistors only

Requirements

a) There shall be no mechanical deterioration;

b) Marking shall remain legible;

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*Basic environmental testing procedures for electronic and electrical items: Part 4 Damp heat (steady state).

c) Maximum change of resistance : as specified in the detail specification;

d) No puncture, flashover or discharge shall occur; and

e) Minimum insulation resistance : as specified in the detail specification.

7.2.10 *Endurance*

7.2.10.1 *Eudurance at maximum voltage* — The thermistors shall be held in position in accordance with one of the methods of clamping given in Appendix A, unless otherwise specified.

Initial measurement — There shall be two options:

Option 1 : All specimens are subjected to Test A.

Option 2 : If required by the detail specification, one half of the specimens shall be subjected to Test A and the other half to Test B.

Test A — The thermistors shall be placed in the test chamber described in 7.1.3, maintained at a temperature of 25°C.

Throughout the test, the thermistors shall be subjected to successive cycles consisting of a 90 min application of the permissible maximum voltage at 25°C, followed by a 30 min rest period. The value of the resistor to be placed in series with the thermistor (R_s) shall be given in the detail specification. The test duration is 1 000 ± 24 h.

Test B — The thermistors shall be placed in the test chamber described in 7.1.3, maintained at a temperature given in the detail specification.

Throughout the test, the thermistors shall be subjected to cylces comprising of a period t_1 with application of the maximum voltage and a rest period t_2.

The values of t_1 and t_2, the number of cycles, and the values of the resistor to be placed in series with the thermistor (R_s) shall be given in the detail specification.

The test duration is 1 000 ± 24 h.

Measurement during test — Zero-power resistance at 25°C.

This measurement shall be carried out at the following stages of the test, after a recovery time of 1 to 2 h : 168 h, 500 h and 1 000 h.

Final inspection and measurements

a) Visual examination,

b) Marking, and

c) Zero-power resistance at 25°C.

Requirements

a) There shall be no mechanical deterioration;

b) Marking shall remain legible, and

c) Change of resistance between the initial measurement and each of the measurements during test : as specified in the detail specification.

7.2.10.2 *Endurance at maximum ambient temperature at zero-power dissipation*

Initial measurement — The zero-power resistance at 25°C shall be measured in accordance with **7.1.1**.

Test — The thermistors shall be placed in a moving-air test chamber, raised to the maximum ambient temperature (± 2°C) and maintained at that temperature for 1 000 h at zero-power.

Measurement during test : zero-power resistance — This measurement shall be carried out at the following stages of the test, after a recovery time of 1 to 2 h : 168 h, 500 h and 1 000 h.

Final inspection and measurements

a) Visual examination,

b) Marking, and

c) Zero-power resistance at 25°C.

Requirements

a) There shall be no mechanical deterioration,

b) Marking shall remain legible, and

c) Change of resistance between the initial measurement and the final measurement : as specified in the detail specification.

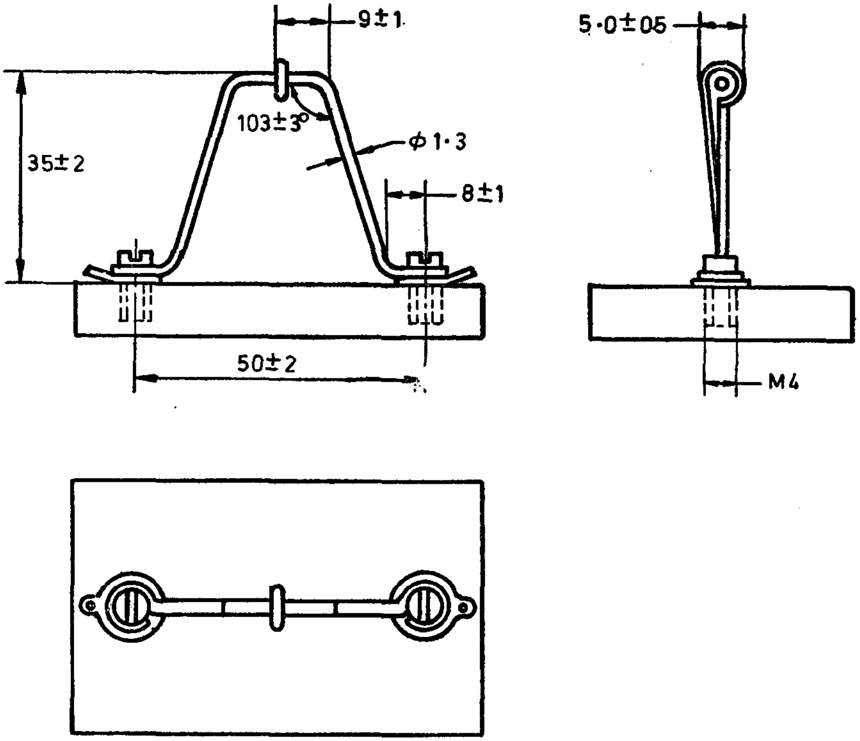
APPENDIX A

[*Clauses* 7.1.1.1, 7.1.3.1(a), 7.1.4.1(a) *and* 7.2.10.1]

MOUNTING FOR MEASUREMENTS OF DIRECTLY HEATED THERMISTORS

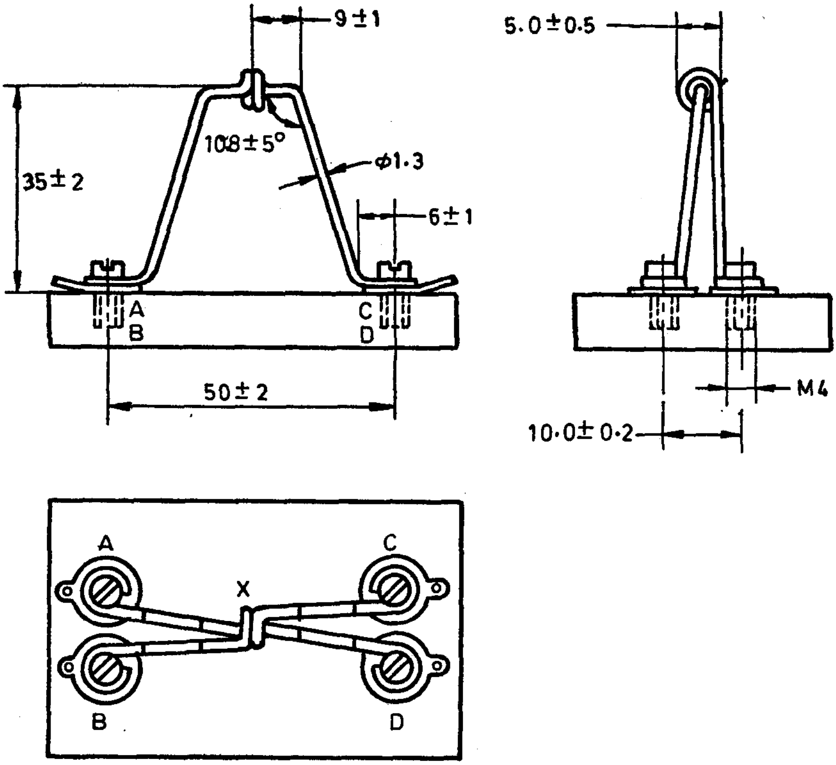
A-1. MOUNTING FOR THERMISTORS WITHOUT LEADS

A-1.1 Thermistors without wire terminations shall be pressed between phosphor-bronze wires of 1·3 mm ± 10 percent diameter, mounted on a base of insulating material, as shown in Fig. 5 and 6.



All dimensions in millimetres.

Fig. 5 Mounting for Values $\geqslant 10\ \Omega$ (Measurement with Two Contact Points)

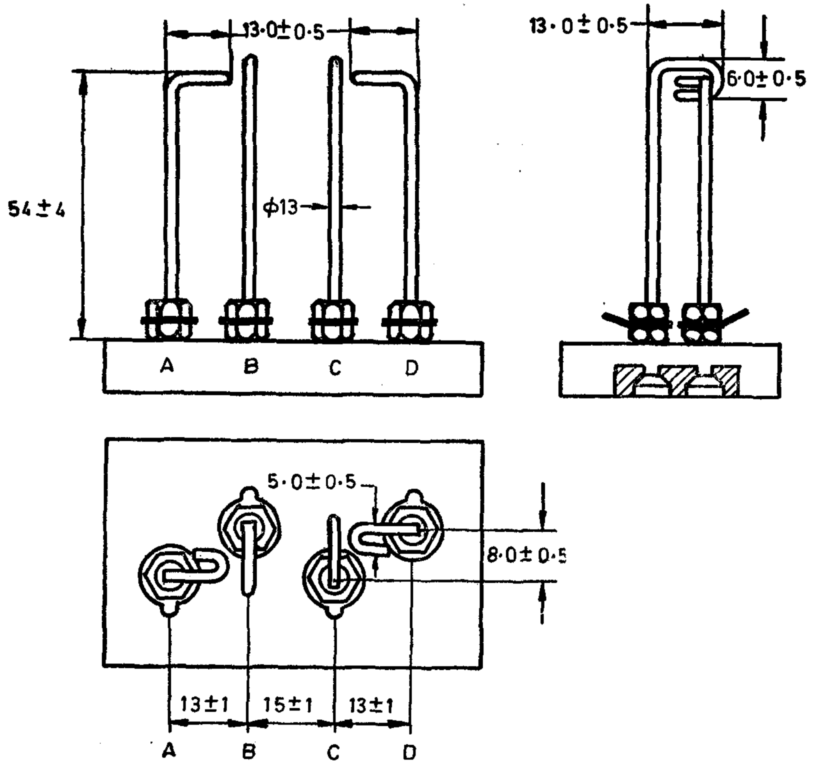


All dimensions in millimetres.

Fig. 6 Mounting for Values < 10 Ω (Measurements with Four Contact Points). The Measurement Voltage Shall be Applied Via an Ammeter to Contacts *A* and *D* (or *B* and *C*) and the Voltage Drop shall be Measured Between Contacts *B* and *C* (or *A* and *D*).

A-2. MOUNTING FOR THERMISTORS WITH LEADS

A-2.1 Thermistors with leads shall be connected (but not soldered) to phosphor-bronze wires of 1·3 mm ± 10 percent diameter, mounted on a base of insulating material, as shown in Fig. 7.



All dimensions in millimetres.

Fig. 7 This Mounting is Suitable for Measurements of High and Low Value Thermistors. For Thermistors of Values $> 10\ \Omega$ Contacts *AC* and *BD* or *AB* and *CD* May be Used Together. For Thermistors of Values $< 10\ \Omega$, the Measuring Method with Four Contact Points Shall be Used. The Measuring Voltage shall be Applied Via an Ammeter to Contacts *A* and *D* (or *B* and *C*) and the Voltage Drop Shall be Measured Between Contacts *B* and *C* (or *A* and *D*)

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

QUANTITY	UNIT	SYMBOL
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

QUANTITY	UNIT	SYMBOL
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

QUANTITY	UNIT	SYMBOL	DEFINITION
Force	newton	N	1 N = 1 kg.m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2